

## REMARKS/ARGUMENTS

Claims 1-18 were finally rejected over the combination of Paulsen et al., Brannon and Hilton et al. Claims 1, 4, 6 and 10 are being amended and claims 5, 13, 14, 17 and 18 are being canceled. Reconsideration of claims 1-4, 6-12, 15 and 16 is requested.

The independent claims have been further amended to more particularly point out and define structures that are within the scope of the original disclosure and patentably distinguishable from the cited prior art. The Examiner's objections are noted and are submitted to be moot in view of the present amendments, which are submitted to place the case in order for allowance.

Independent claims 1 and 10 have been amended to expressly highlight the following structural points:

- (a) The four and only four arms are defined as "transversely flexible but axially stiff".
- (b) The four arms are stated to be in a substantially tetrahedral array.
- (c) The four connection joints (each between a respective arm and a common gripping device) are defined as a cylindrical socket with an axis substantially aligned with the axis of the arm and the use of a part-spherical engagement element which is slideable along the socket and rotatable in the socket.
- (d) This interaction between the components inherently results in applied torque and/or force resolving into four opposing forces which lie in the faces of this tetrahedral array and are normal to the axes of the arms and no axial load is applied to the arms.
- (e) The structure inherently provides transverse displacement in the arms to be monitored by the detector.

Thus, one of the features in the combination of claim 1 is a substantially tetrahedral array of arms, and this exploits spatial consistency and rotational response and thus is an important choice among possible arrangements which works in combination with the other features.

Differences between the amended claims and the cited art (considered both individually and in combination) will now be discussed.

Paulsen neither discloses nor suggests at least the following features of claim 1:

- (a) Paulsen resolves force and torque into three intersecting forces applied along axes of the arms or suspensors and torques are resolved as three orthogonal forces.

This is so even if the option mentioned in the text of Paulsen, namely a tetrahedral array, is used.

- (b) Paulsen also has a structure which requires a transversely flexible and axially stiff arm but the axial stiffness opposes the applied forces and thus there is axial load along the arms. Thus the Paulsen disclosure operates in a mode and has a structure which is very distinctly different and is fundamentally designed on different design concepts and differs from the explicit structure in the amended claims, particularly the claimed connection joints. The relative axial movement and rotational displacement in each of the joints is completely absent from Paulsen and Paulsen's design approach not only has no such joints but needs no such joints to implement his concept which concerns axially rigid arms or suspensors.
- (c) Paulsen does not propose any detection arrangements which rely on transfer displacement of the arms for monitoring. The claimed structure thus inherently provides an elegant and effective device providing a linear response to applied torque and applied force with homogenous sensitivity.
- (d) An effect of the claimed device is that the device significantly decouples the force and torque responses because of the nature and array of arms and joints. This ensures a consistent spring constant in both a translational and a rotational sense. Paulsen does not provide this feature because he is designing for a flexural pivot for a particular application in aircraft and relies on rotational feedback. Paulsen is concerned with rotation response and not translation.

Regarding Brannon, the Examiner appears to have framed an obviousness argument against the previous claims on the basis that it would be obvious to take the suggestion of a tetrahedral array from Paulsen and then apply it to the Brannon approach thereby leading to the claimed device. For the reasons particularized below, it will be apparent there is far more to the present claimed combination than simply that inherent in the Examiner's argument. And further, both Paulsen and Brannon are founded on fundamentally different design concepts, such that reading the disclosures together, even with the legally improper benefit of hindsight, would not lead the ordinarily skilled person to the present advantageous combination.

- (a) The first embodiment of Brannon has four arms which are transversely flexible but also axially flexible and not stiff as is now emphasized in the amended claim 1. Thus this embodiment is based on a fundamentally different arrangement which is essential to make the design notion of Brannon work.
- (b) There is no suggestion in Brannon of changing the arrangement to a tetrahedral array and a person ordinarily skilled in the art could not reasonably be supposed

to give consideration to altering Brannon to a tetrahedral array, because it would make no sense to depart from the planar arrangement disclosed and required by Brannon.

- (c) Brannon's concept is to use a grip which provides complicated displacement and rotational responses to the applied force and applied torque, in contrast to that inherently arising by the elegant structural arrangement in the present main claims as revised. Merely notionally adapting the first embodiment of Brannon to a tetrahedral array does not resolve the forces to lie in the planes of a tetrahedron as specified in the present main claim as revised. In terms of specific structure Brannon does not in any way suggest having in the first embodiment the connection joints as defined in the present claim and neither does Brannon teach or in any way lead towards having transversely flexible arms. Brannon's arms are axially and transversely flexible.
- (d) By contrast, a consequence of the specific structure defined in the amended present claims leads to a linear response to applied torque and force with homogeneous sensitivity.
- (e) As to the second embodiment of Brannon having two versions, namely a four-arm version in Figure 5 and a three-arm version in Figure 6, we observe all the arms are in a plane, and it is plain the arms are axially stiff and also transversely stiff as the disclosure is for applying the torque and force from the grip to apply load to sensors. There is no suggestion of a tetrahedral array and a person skilled in the art could not reasonably suppose it would be a reasonable development to change the Brannon embodiments to a tetrahedral array. This is because the Brannon arms need to be rigid to work as disclosed. Furthermore, there is no suggestion of connection joints as defined in the present claims and no suggestion of detecting displacement transversely in the arms, simply because in Brannon the arms are rigid and no question arises of working in this way.
- (f) Brannon is quite different and concerns a design measuring force and torque in a planar arrangement. This arrangement is potentially disadvantageous because developing an accurate device could be a significant problem as there is no spatial consistency unlike the use of the tetrahedral array with the joints specified in the present claims.
- (g) In the case of Brannon, the resolution in the response dramatically varies as one moves away from the origin and by contrast, the present arrangement is highly advantageous by not having such a deleterious feature. More particularly, Brannon thus does not lead towards the solution or suggest anything which could lead one to the present combination.

It is submitted that when the prior art is reconsidered, without any benefit of hindsight, it will be seen that without knowing the present inventive combination of claims 1 and 8, neither

Brannon nor Paulsen, nor any combination of the two, would teach an approach which is as elegant, effective and capable of effective performance in a novel manner as is achieved by the device as defined in the present claims.

Moreover, the presently claimed inventive concept can be more fully explained from a theoretical point of view in terms of mechanical engineering and joint theory. Perhaps the simplest way to differentiate Hilton's claimed device is to consider the four resolved forces:

- The device mechanically resolves a general force and torque applied to the grip into four opposing forces that pass through the four centers of the part spherical arm tips, these forces being substantially normal to the axis of each arm and so lying substantially parallel to or in the four surfaces of a tetrahedron. Summing the applied force and the opposing forces equals zero. Summing the applied torque and moments of the four opposing forces is zero.
- The device then senses at least six of the eight values comprising the four 2D force vectors by sensing the transverse deflection of the transversely flexible and axially stiff arms.
- Where required the remaining 2 opposing force values are calculated from the six sensed values and the resulting four 2D force vector values are used to calculate the applied general force and torque vectors.

Resolving a general applied force and torque into four tetrahedrally arranged 2D force vectors is not suggested by the known art.

Paulsen's device opposes the general applied force with forces occurring in and along the axis of the suspensors. Hilton's device, as now claimed, has substantially no force along the axis of the arms. The suspensors do not oppose the general applied torque. Hilton's arms oppose the general applied torque. The resulting Paulsen device is a flexural pivot and it can be constructed with any number, four and above, of spatially arranged flexural members. Additional means, disclosed as three orthogonally arranged devices, are used to provide and detect the forces opposing the general applied torque. Hilton's device does not require additional opposing or detection means completely separate from the arms.

Brannon's first device, figures 1 and 2, has four elastic tubes, 33-36, to provide both transverse and axial flexibility. Hilton's arms are only transversely flexible. The resulting four opposing forces pass axially along the tubes and through the ends of the four rods, 37-40. Hilton's four forces are normal to the four arms. Brannon's four opposing forces do not remain in a plane normal to the rods as is the case with Hilton's four opposing forces. Brannon's four forces are 3D in nature, a total of 12 values compared with Hilton's 8 values. Brannon does not

detect any forces but instead senses four pairs of angles. Hilton's device uses sensors designed to detect a displacement corresponding to a force, not to detect an angular displacement as Brannon does. Further, Brannon's device exhibits a cross coupling and non-linear displacement response between the applied force and torque. For example, the amount of displacement due to a given applied force will be different when there is no applied torque compared to the force induced displacement when there is an applied torque. Hilton's device both decouples the force and torque displacement response and also has, by design, a linear response where any delta change in force, ignoring the miniscule error terms, produces the same delta translational displacement and any delta change in torque produces the same delta rotational displacement and so, in effect, creates an homogenous spatial spring. The ergonomic feel of an homogenous spatial spring is of great benefit.

Brannon's second type of device, figures 5 and 6, does not have a tetrahedral arrangement. The arms, 45-48 and 57-59, are rigid both transversely and axially, unlike Hilton's. The detection means detect the force the arms apply to the base, not the deflection of the arms as with Hilton.

In view of the amendments herein, and the foregoing remarks, reconsideration and allowance of the amended claims is respectfully requested.

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TRADEMARK OFFICE EFS FILING  
SYSTEM ON August 14, 2009.

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Respectfully submitted,



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